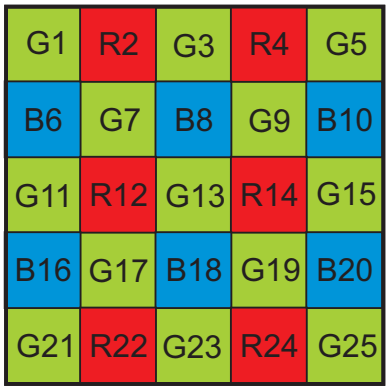
# Tutorial 1

## Problem 1.1

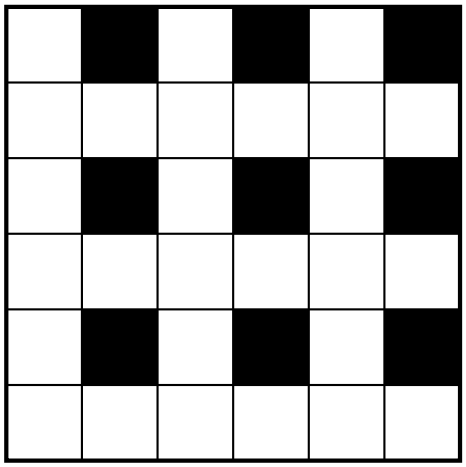
An image is taken with a 1-chip CCD color camera with a built-in Bayer pattern as color filter array (CFA).



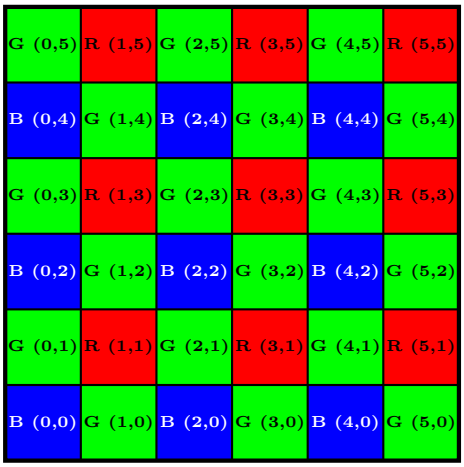

For each pixel in the output color image, the values of all three channels (R,G,B) are required. According to the pattern, two color values are missing for each pixel. How can these missing values be interpolated?

## Problem 1.2

The black-and-white picture shown in Figure (a) is acquired by a 1-chip CCD camera with the Bayer-pattern shown in Figure (b) as the color filter array und using bilinear interpolation of missing color values. The pixel grid of the picture shall be aligned to the pixel grid of the camera. White shall be assigned to the maximum values 1.0, black is assigned to 0.0. Assume the pattern of the picture as well as the CCD to infinitely extend in horizontal and vertical direction.



(a) Picture to be acquired



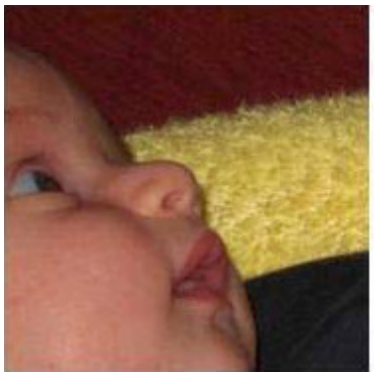

(b) Bayer pattern of the camera

- Compute the color values at pixel positions $(2,2)$, $(2,3)$, $(3,2)$, and $(3,3)$ and name the resulting colors.
- Assume the picture to be shifted by an offset of $+1$ pixel relative to the array in both vertical and horizontal direction. Compute the color values at pixel positions $(2,2)$, $(2,3)$, $(3,2)$, and $(3,3)$ and name the resulting colors.

## Problem 1.3

Original pictures (to the left) and manipulated versions thereof (to the right) are shown below.






Forensic image analysis tries to disclose such fraudulence. Often, forgery is disclosed due to inconsistent illumination, e.g. when analyzing reflection in the eyes of depicted persons.

Commonly, pictures are taken by cameras with Bayer-pattern. Can this information and the knowledge of potentially applied demosaicing algorithms be used to detect manipulation of images?

Example references:

A. Dirik and N. Memon, "Image tamper detection based on demosaicing artifacts", IEEE ICIP'09, Cairo, Egypt, 2009.

M. K. Johnson and H. Farid, "Exposing digital forgeries through chromatic aberration", ACM Multimedia and Security Workshop, Geneva, Switzerland, 2006.

## Problem 1.4

Calculate the diameter of the smallest possible printed dot to be visible for the human eye on a sheet of paper in the distance of 0.2 m from the eye. For simplification, only the laws of geometric optics shall be considered here. Assume that the dot is detected if the projection to the fovea has at least the size of the diameter of a cone cell.
Hints: In the fovea region, 160.000 cone cells are available on 1 $mm^2$. Assume an uniform distribution of cone cells and intermediate space. The focal length of the human eye is in the range of 14 mm and 17 mm.